CRISP / Detector & DAQ / WP15
2011-2014

WP15 Objective

Demonstrate that the “^{10}B thin film Multi-grid” developed during ILL20/20 is competitive in performance and cost with ^{3}He detectors.

Method

Fabrication and test of a large area demonstrator

EUROPEAN SPALLATION SOURCE
Linköpings universitet
INSTITUTE OF TECHNOLOGY
NEUTRONS FOR SCIENCE®

around 40 people have been involved in this development :

Linköping University

Mewlude Imam, Agne Zukauskaite, Olof Tengstrand, Jens Birch, Lars Hultman, Susann Schmidt

CERN

Will Vollenberg

ESS, Lund

Anton Khaplanov, Carina Höglund, Maddi Echegaray, Irina Stefanescu, Richard Hall-Wilton, Scott Kolya, Robert Anderson, Björn Nilsson, Erik Nilsson, Luis Ortega, Christian Vettier, Markus Preston, Ramsey Al Jebali

ILL, Grenoble

Thierry Bigault, Jean-Claude Buffet, Jonathan Correa, Jean-Francois Clergeau, Sylvain Cuccaro, Mathieu Ferraton, Bruno Guérard, Sylvain Jonchery, Marek Koza, Jerome Pentenero, Francesco Piscitelli (ESS since 2014), Patrick Van Esch, Gilbert Viande

+ all who helped in the organization: Eileen Clucas, Miriam Forster, Johann Heuser, Michael Krisch, Isabelle Petit, Agnes Ratel, Martin Walter, …

WORK PLAN

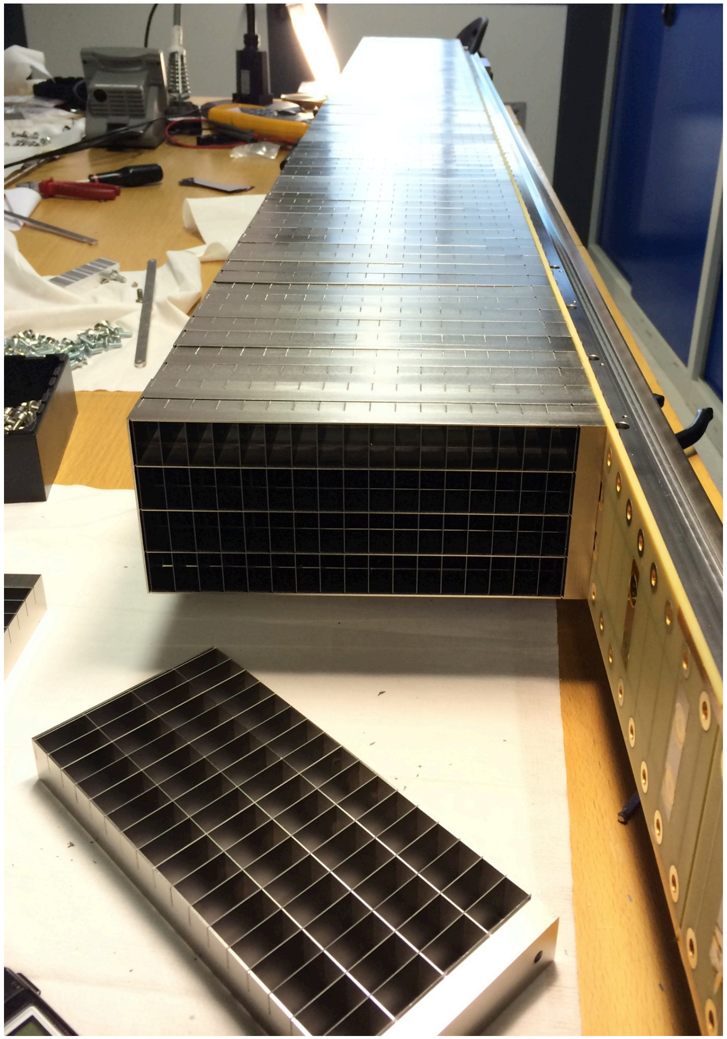
T1 Boron film fabrication studies

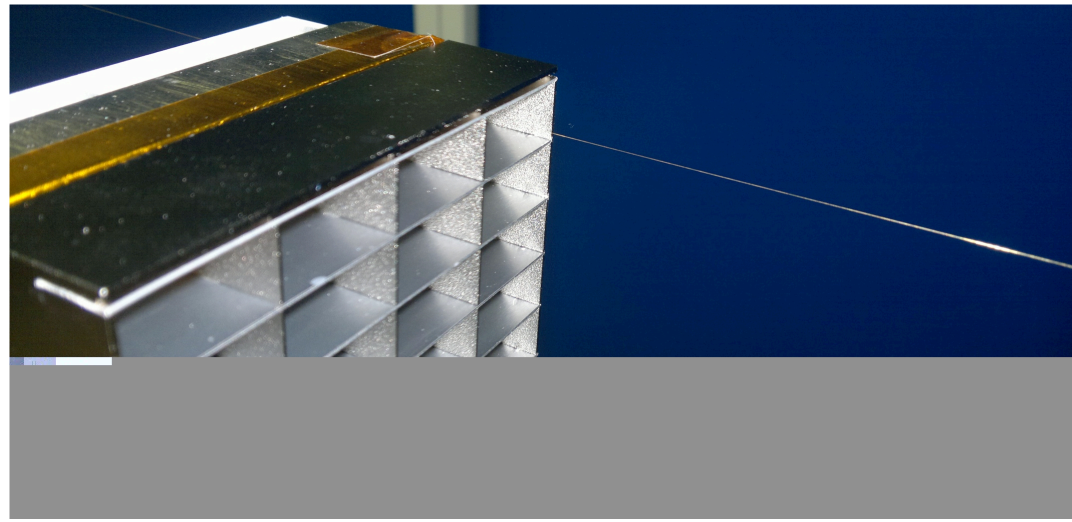
T2 Detector design study with prototypes (report MS5)

T3 Large Area detector study (report MS20)

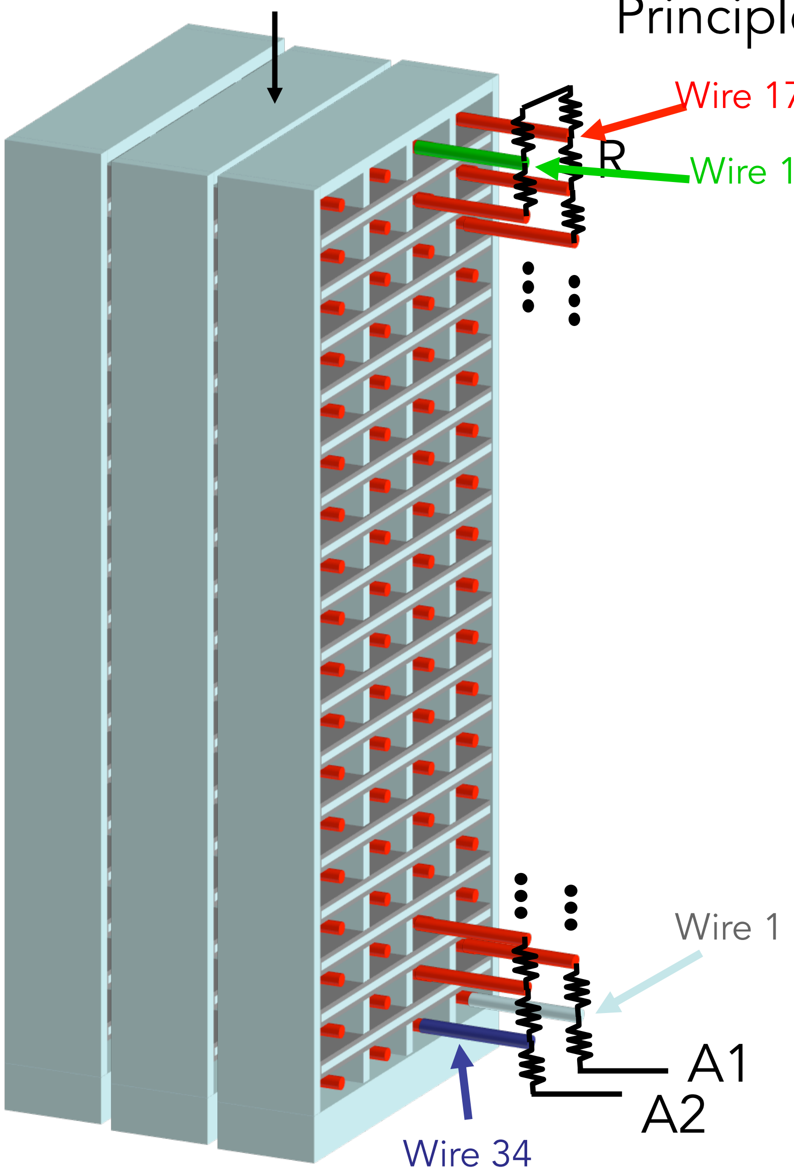
T4 Demonstrator fabrication & test (report D15.1)

Principle: Internal mechanics





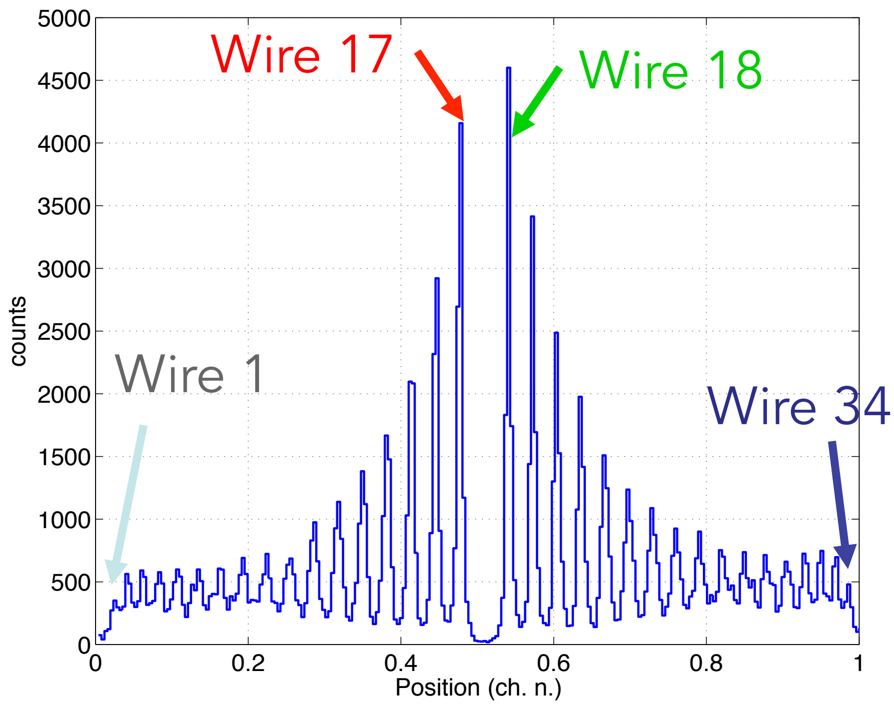
Principle: Electronics



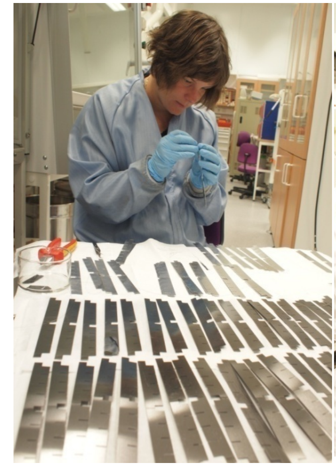
Charge division read out

17 x 4 = 68 wires

Readout by only 4 outputs



T1 Boron film fabrication studies



MC Simulation, calculations

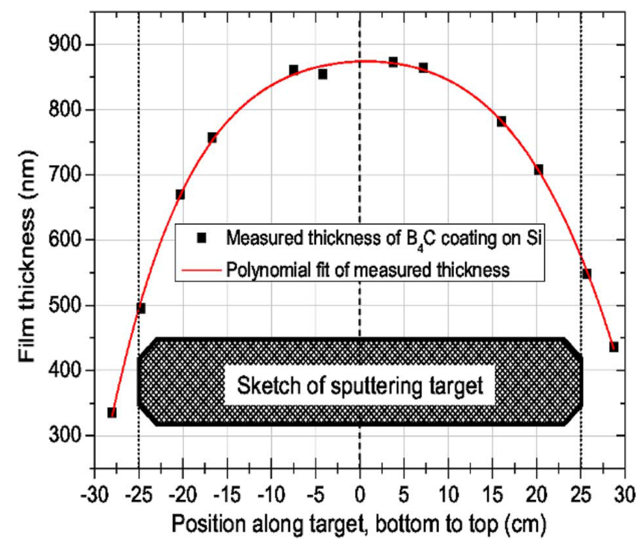
- optimal thickness, effect of impurities

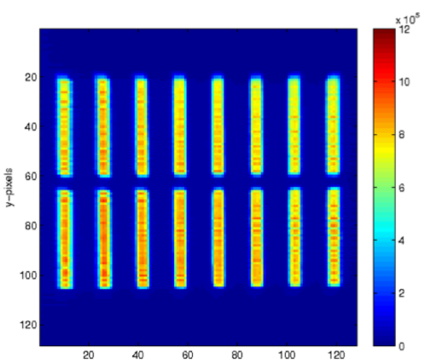
Study of PVD and CVD processes, thin film analysis

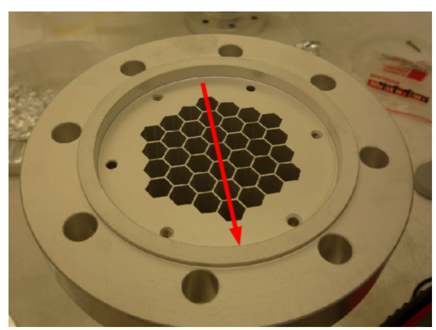
- optimization of film quality and production

Tests on beam lines at different wavelengths

- Discripancy between measured efficiency and film characterization → improvement of the MC simulation + better control of film thickness (gradient due to target/sample geometry)

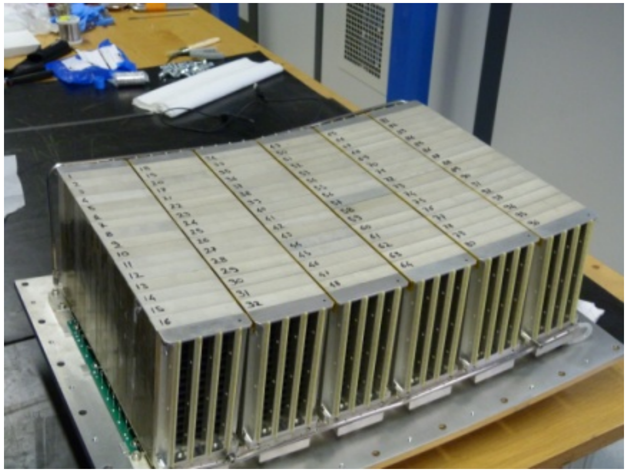






T2 Detector design study with prototypes

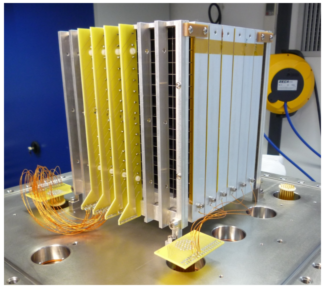
5 different prototypes have been fabricated and tested
6 grids, 12 grids, 96 grids_2m, 96 grids_IN6, 128 grids_demo_test



Many experimental results:

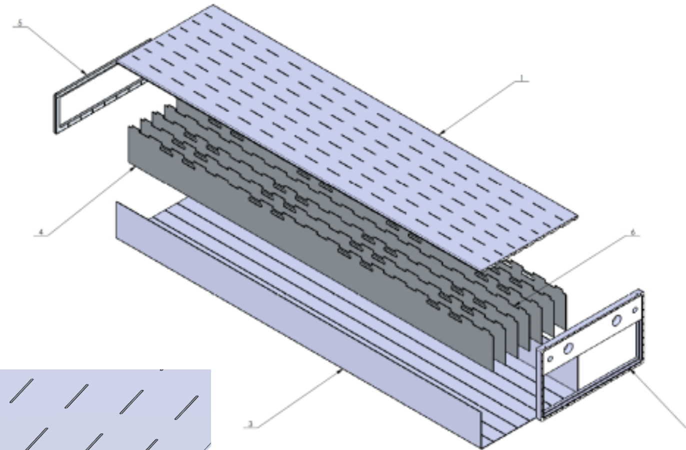
- Detection efficiency versus thickness, & versus gamma sensitivity
- Alpha background and Neutron scattering reduction
- Measurement of the wall effect
- Spatial uniformity
- Electronics readout scheme optimization
- TOT Centre Of Gravity algorithms
- Mounting procedure of the detector (grids, wires, connectics)
- Operation versus gas pressure from 10 mb to 1 bar
- Optimization of the gas flushing procedure
- Counting stability
- Study of different Grid designs
- Tolerance to mechanical deffects

….



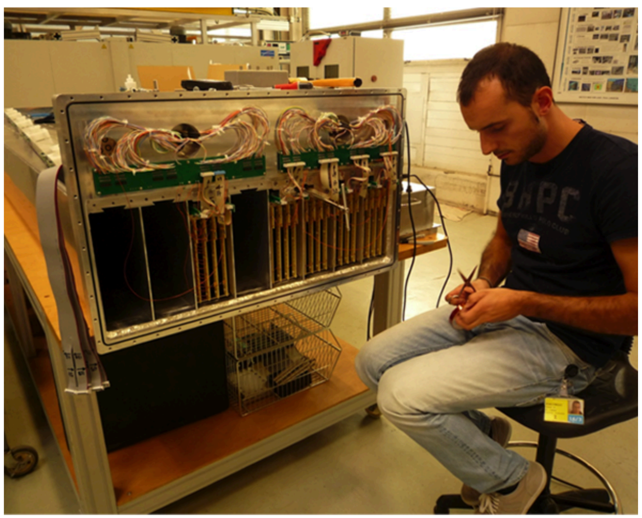
T3 Large Area detector study

- Mass production of ^{10}B films.
- Technical specification of the demonstrator compatible with operation in a vacuum TOF chamber



Detector Coatings Research Leads to ESS Production Facility in Linköping

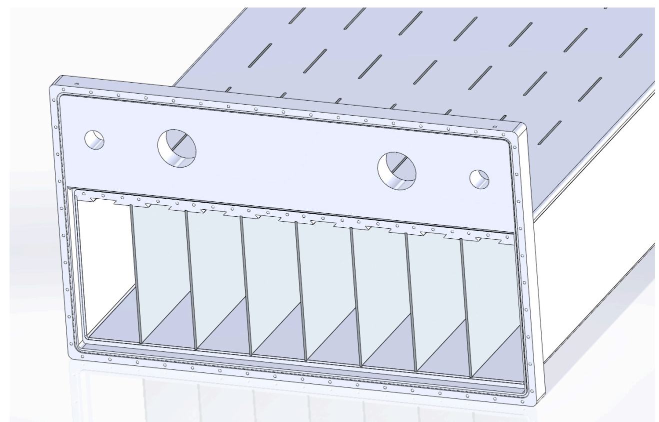
NOV 7, 2014

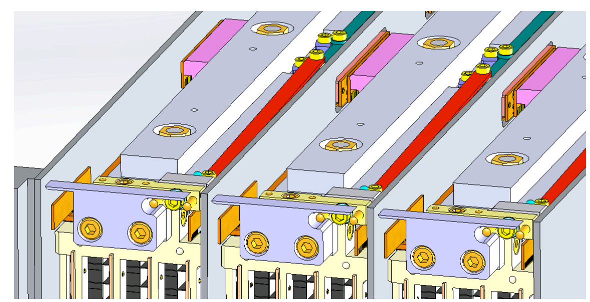


ESS, Institut Laue-Langevin and Linköping University. The little building with the forgettable name has the attention of neutron science facilities across Europe.

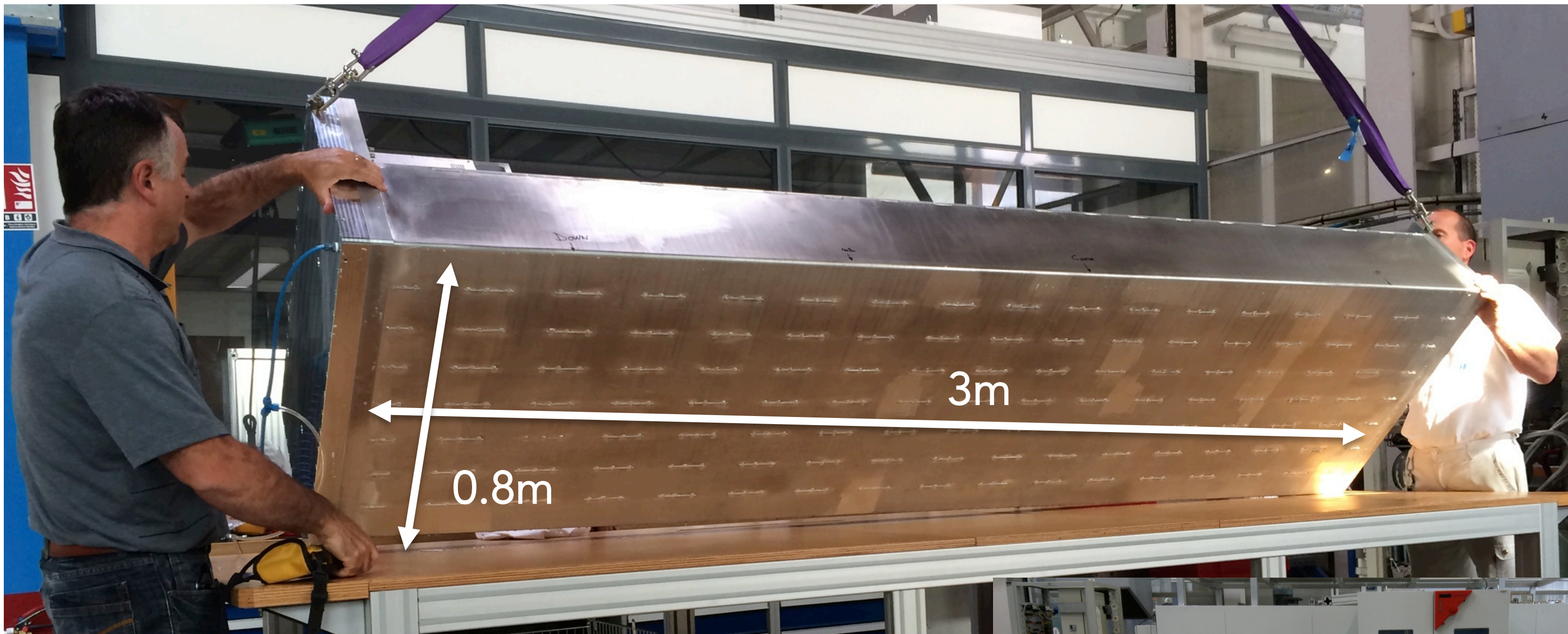
LUND, GRENOBLE, LINKÖPING — The European Spallation Source (ESS) and Linköping University (LiU) are holding a ceremony to inaugurate the ESS Detector Coatings Workshop in Linköping,

Above: Francesco Piscitelli (ESS/ILL) working on the large *MultiGrid* detector prototype (3 m x 0.8

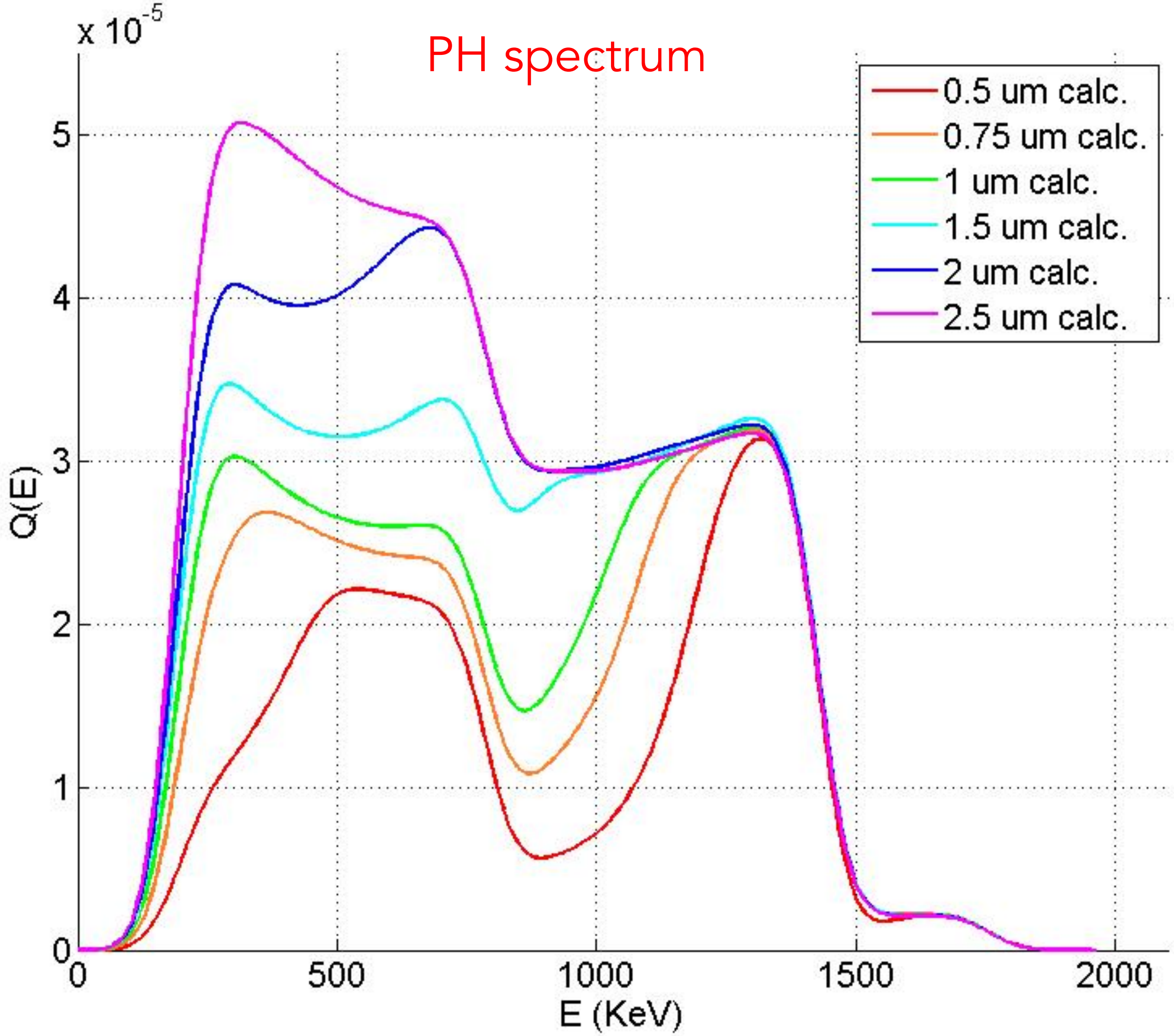




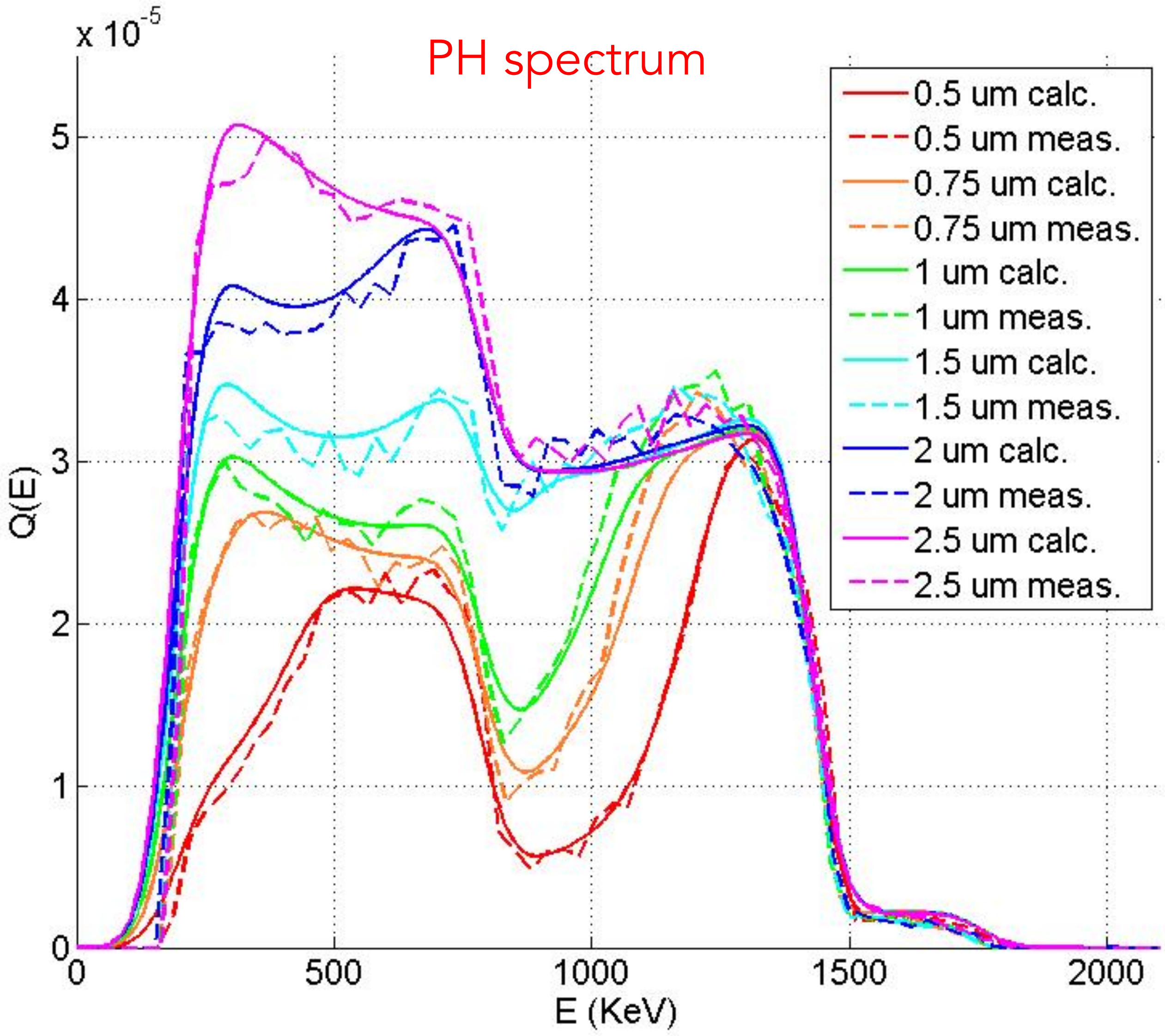
T4 Demonstrator fabrication & test



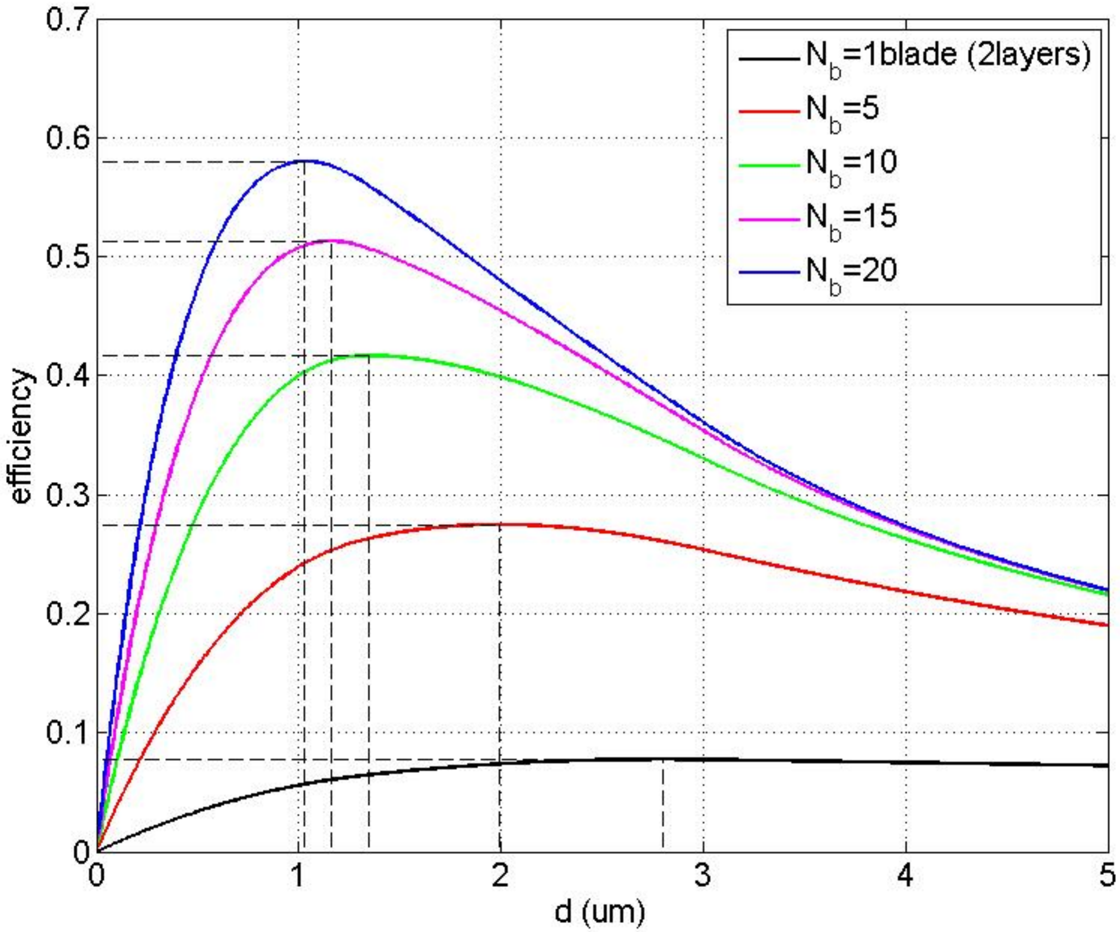
Calculated


PH spectrum
x 10^-5
Q(E)
E (KeV)
0
1
2
3
4
5
0
500
1000
1500
2000
0.5 um calc.
0.75 um calc.
1 um calc.
1.5 um calc.
2 um calc.
2.5 um calc.

Calculated & Measured

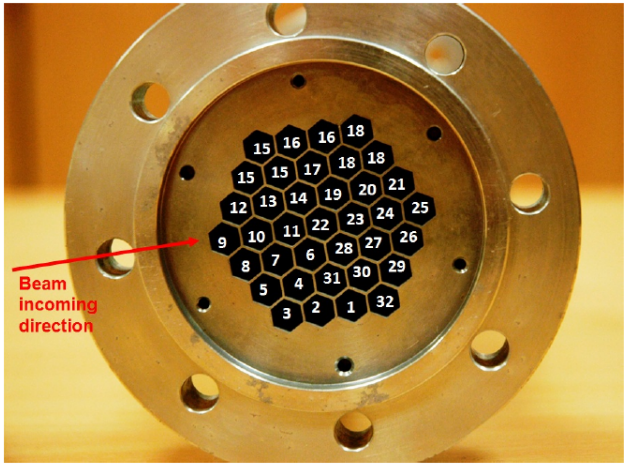


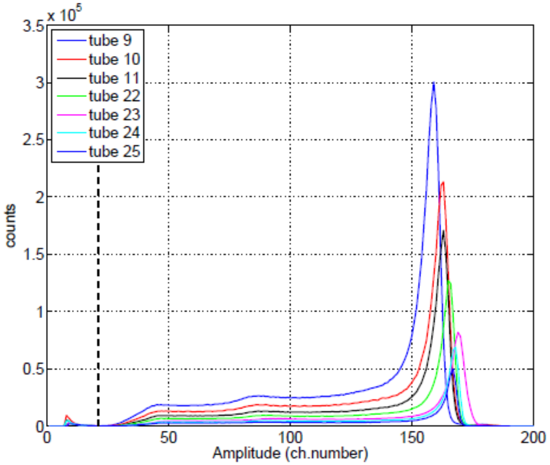
(Θ=90˚, 1.8Å)

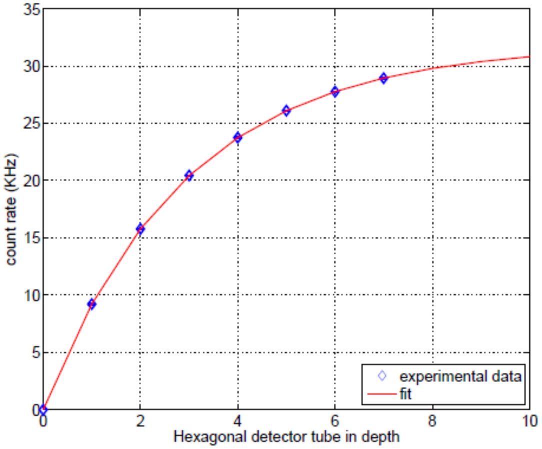

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
efficiency
0
1
2
3
4
5
d (um)
N_b=1blade (2layers)
N_b=5
N_b=10
N_b=15
N_b=20

Method for measuring the detection efficiency

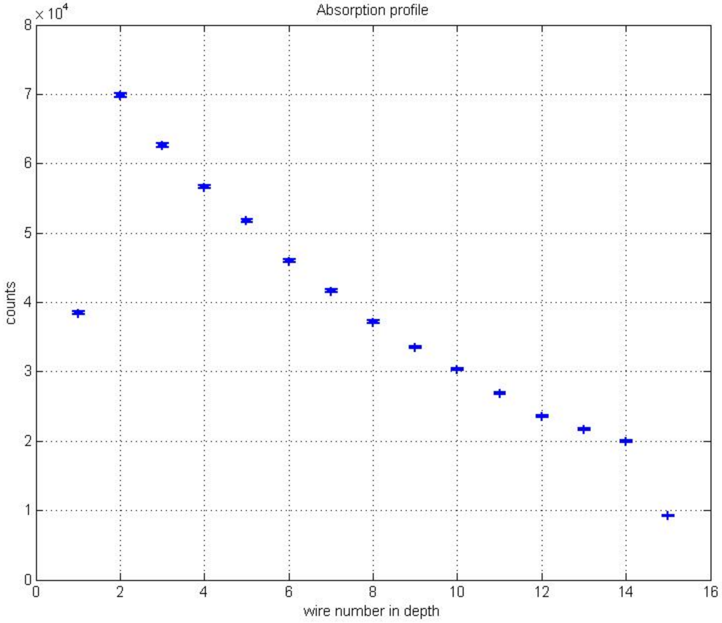
3bar ^3He +
1bar CF_4

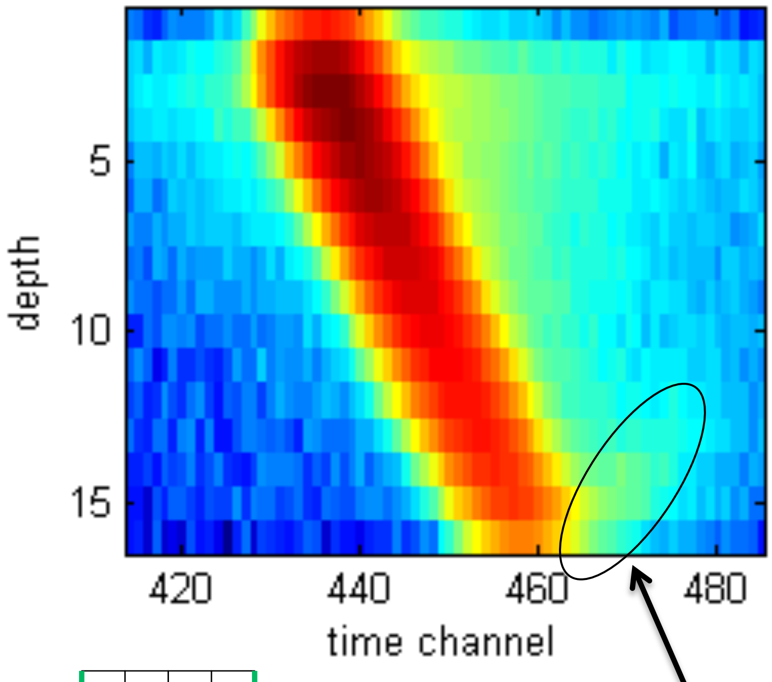


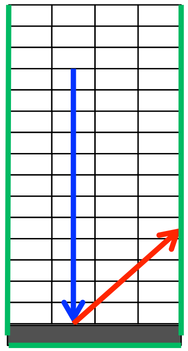




52 % measured @ 2.5A
With a prototype
containing 28 B4C films

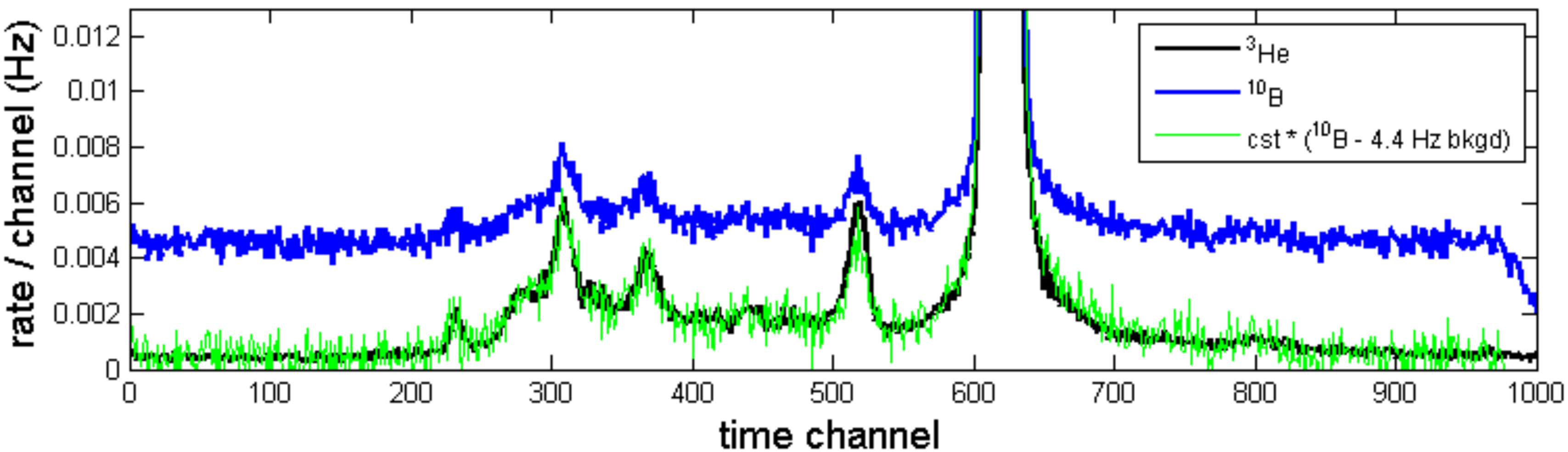






θ (4.1 A) = 122°

Background noise

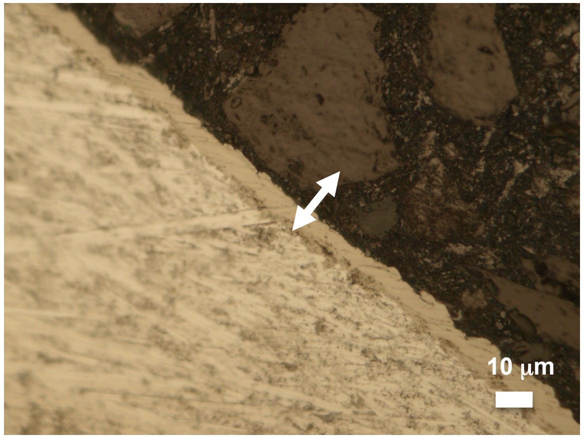


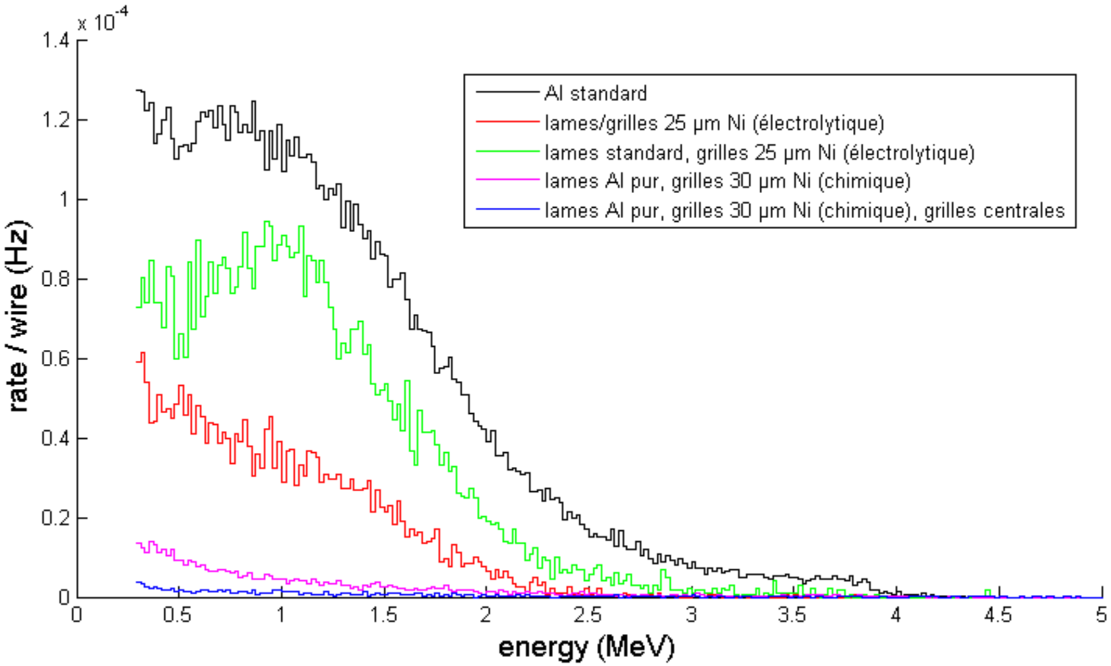
4.4 Hz flat background was observed (**no time structure**)

→ independent of the IN6 instrument / reactor

→ uniform throughout detector

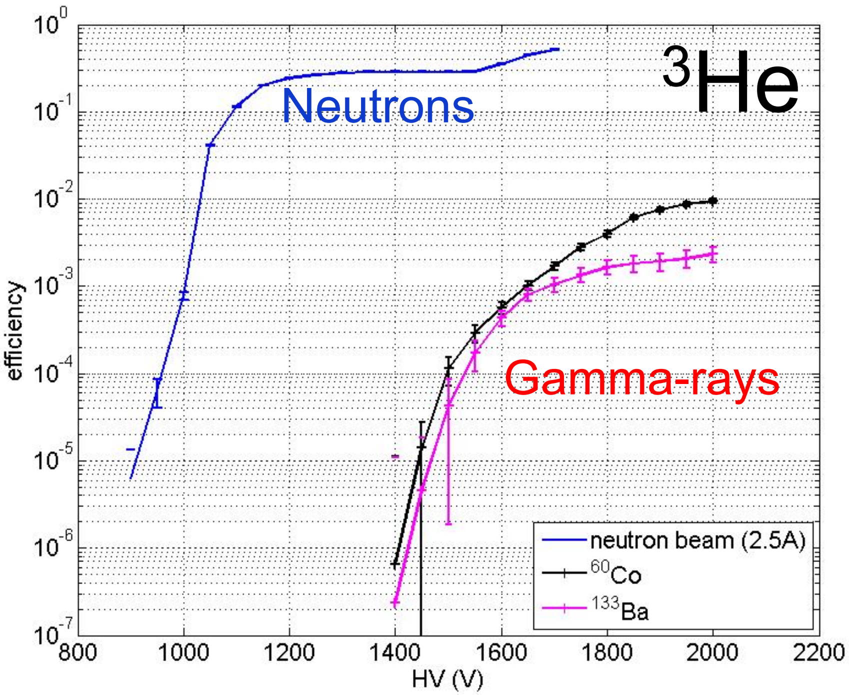
Background noise supression

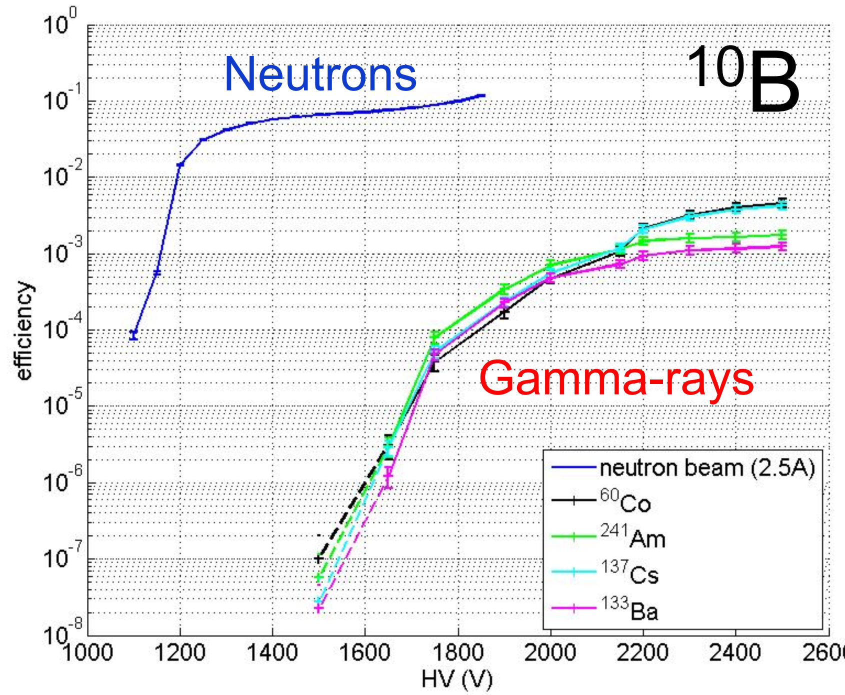




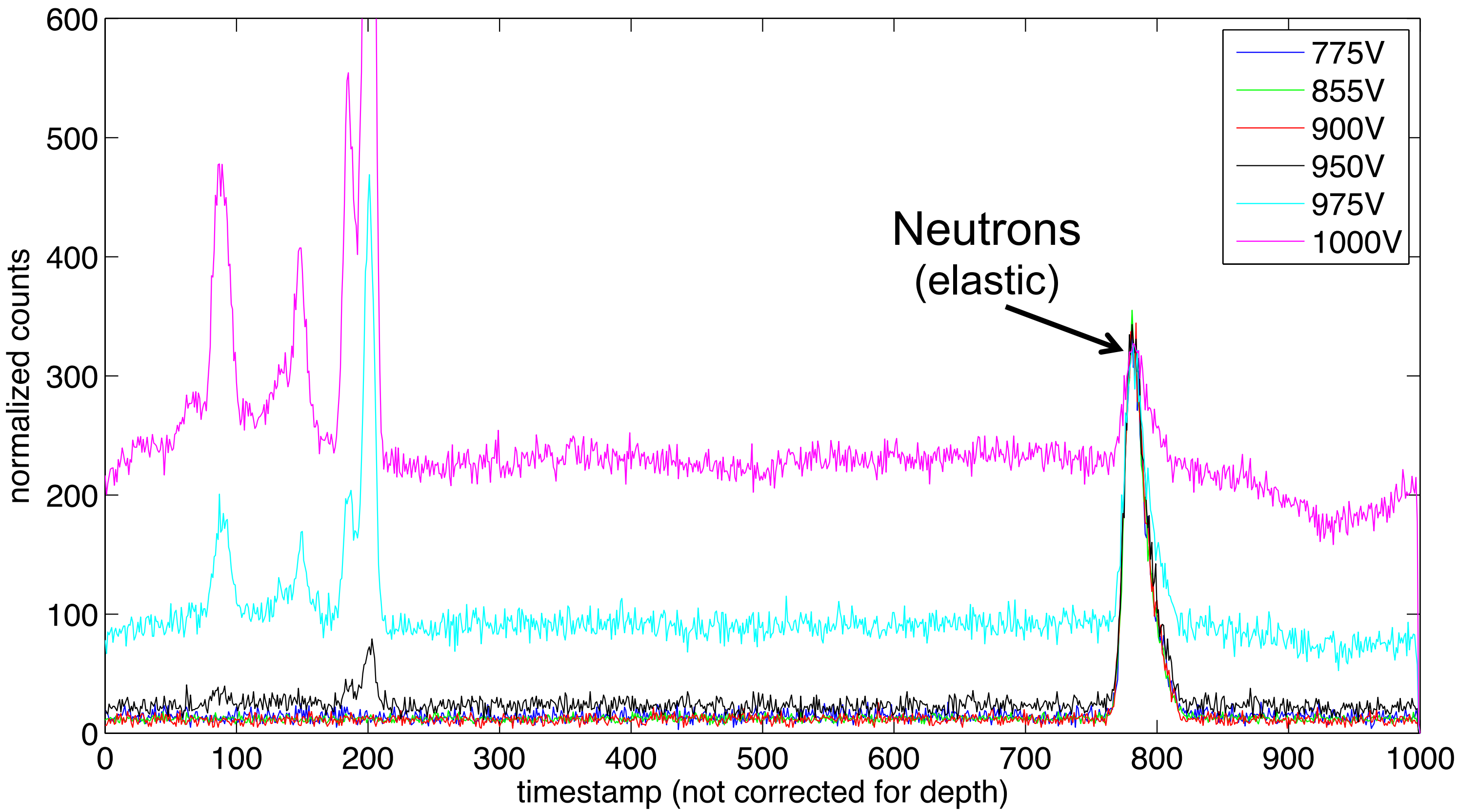
1. Ni layer Electrolytic deposition
2. Ni layer Chemical deposition
3. Al pure

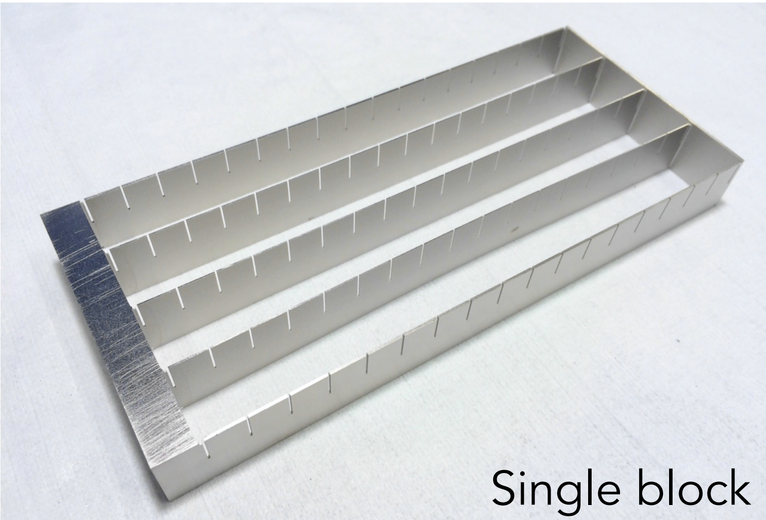
Gamma sensitivity

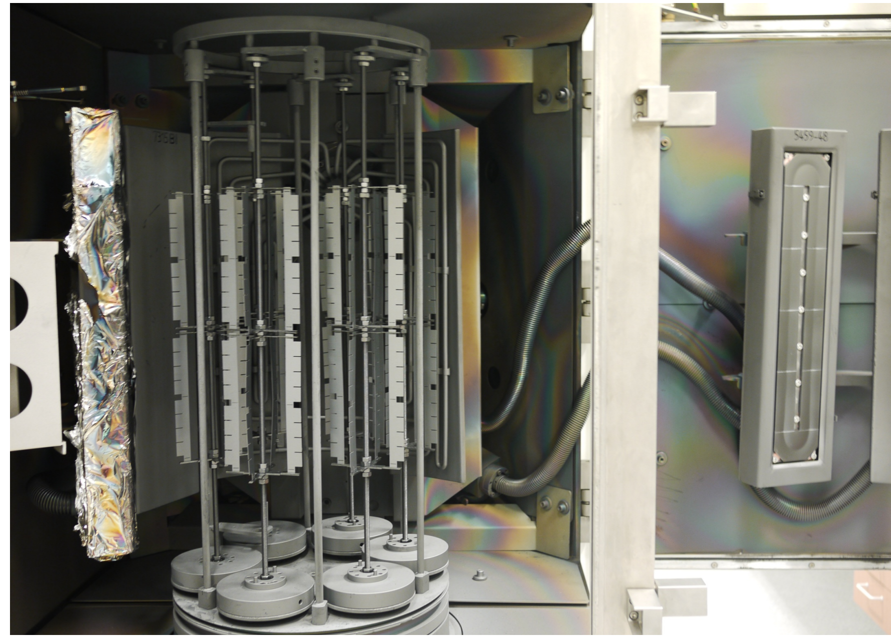


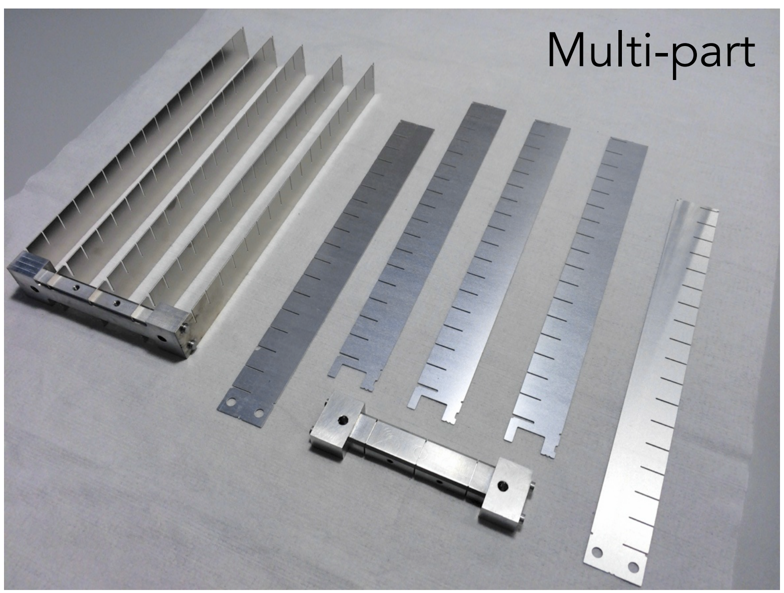


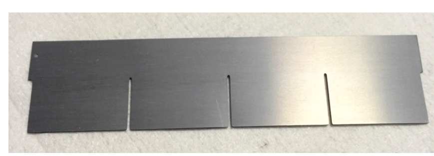
Gamma sensitivity

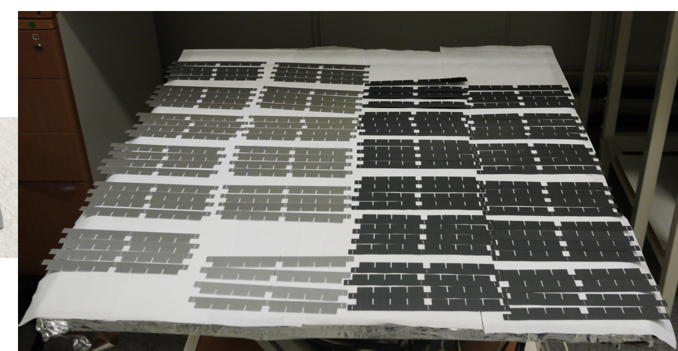


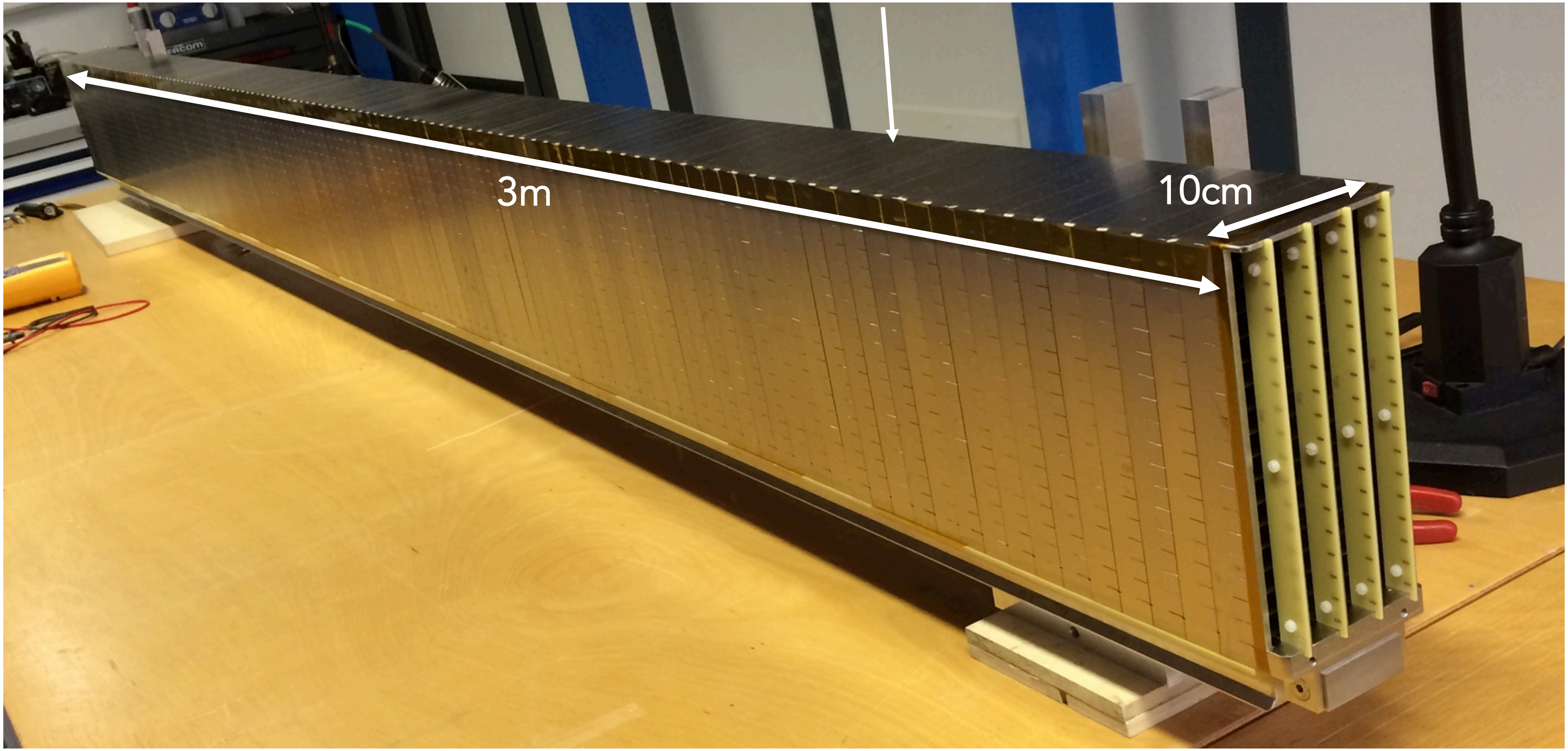

Single block



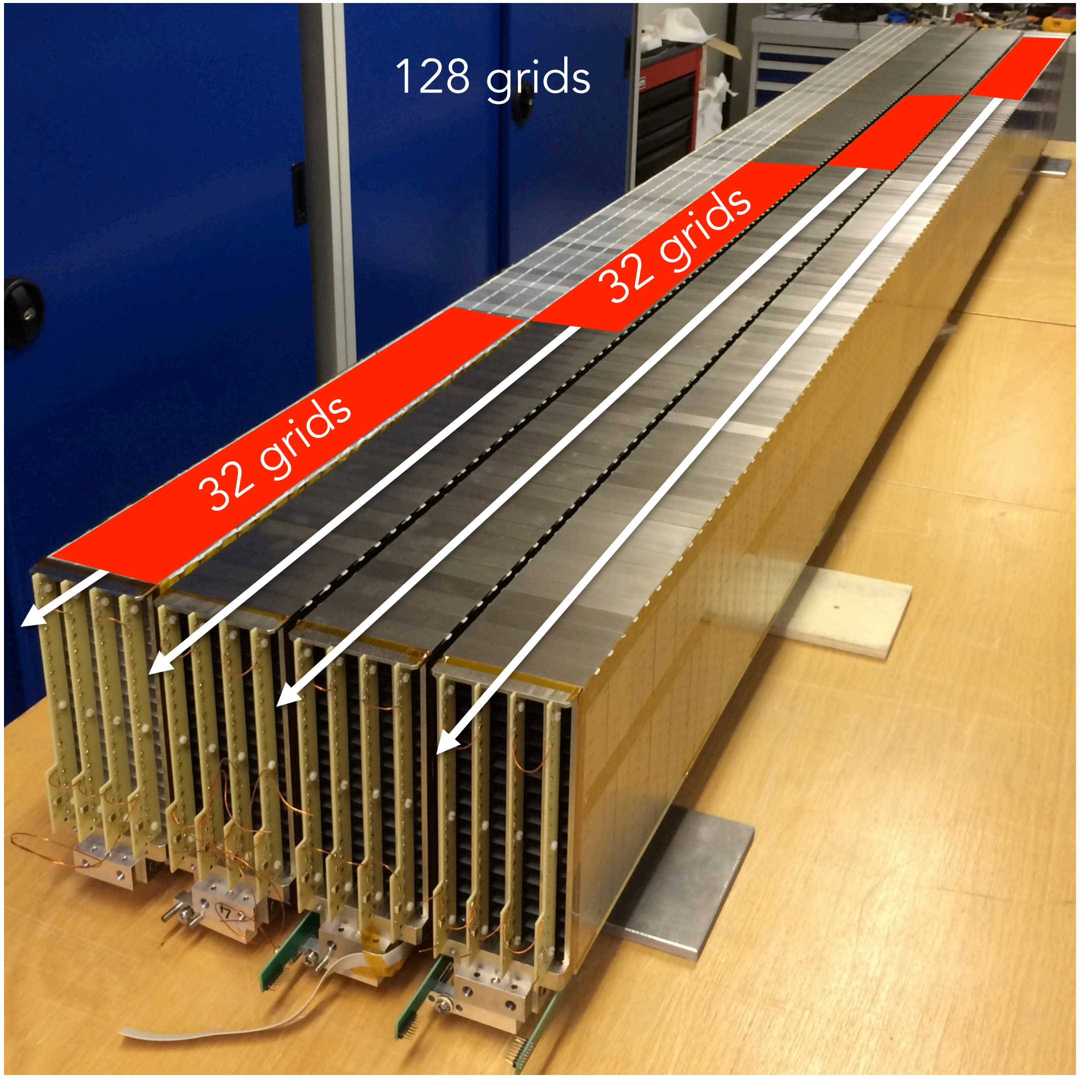

Multi-part

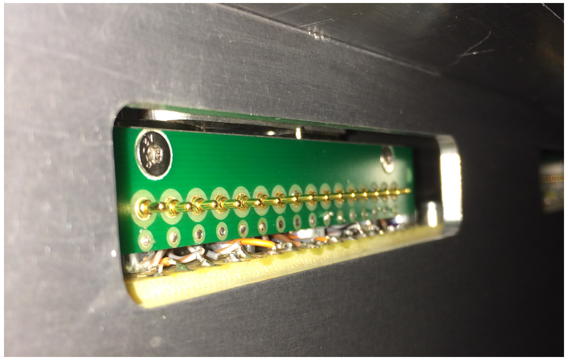


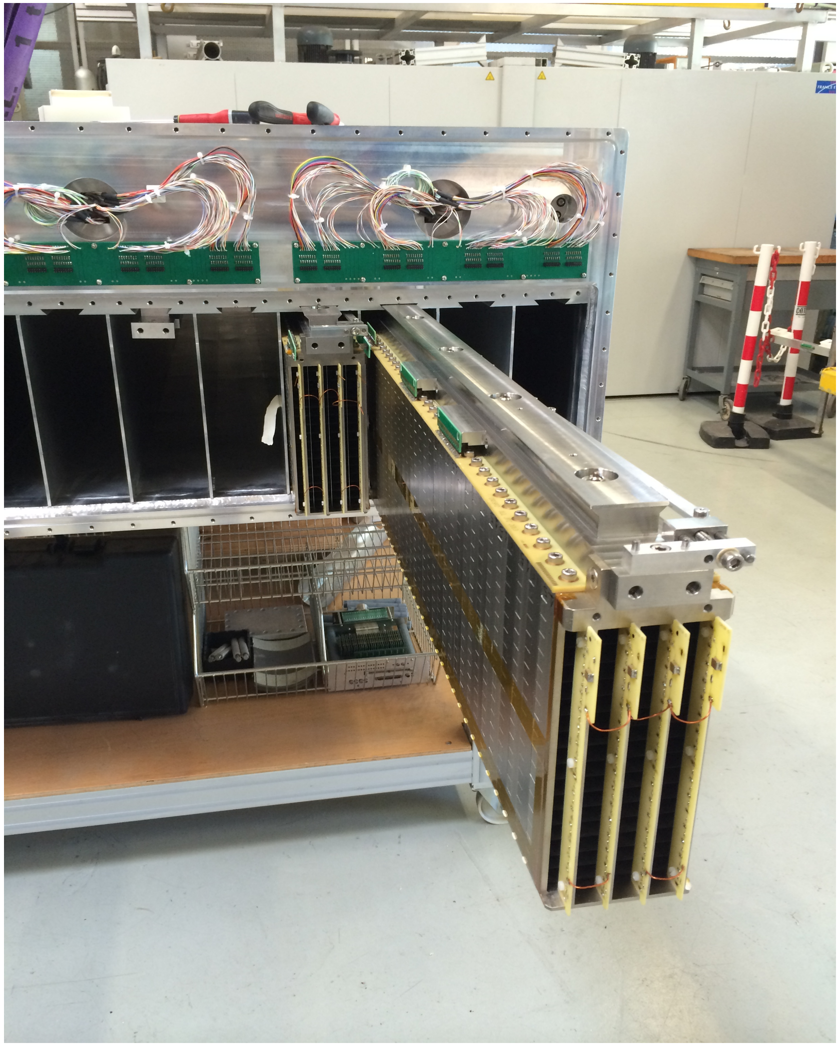


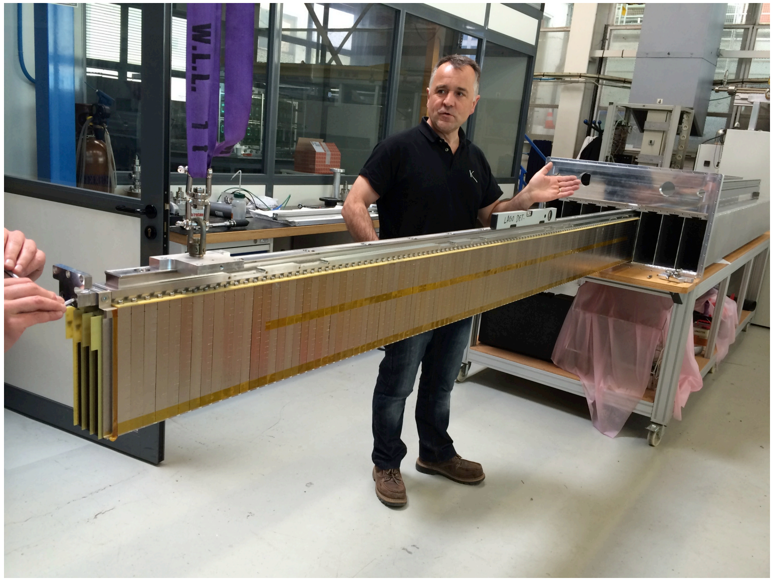


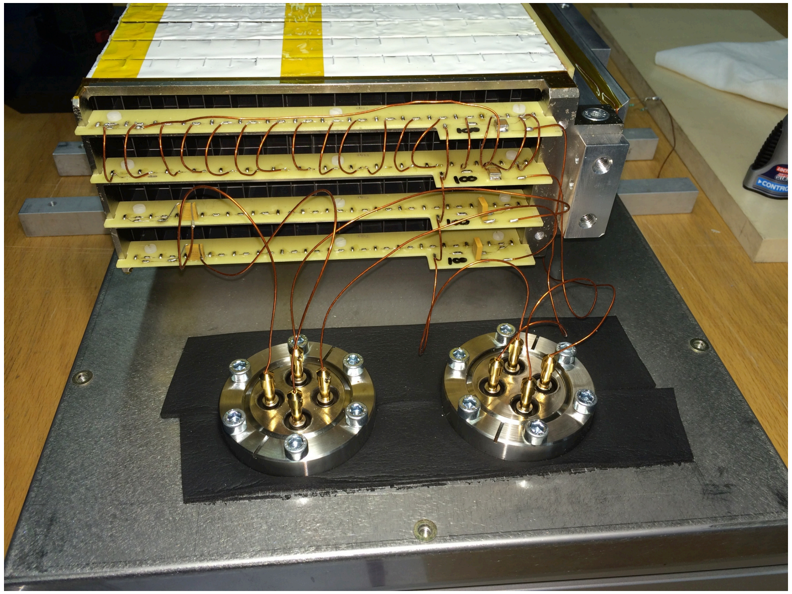
1 Column : 128 grids x 34 $^{10}B_4C$ layers ~2000 Blades


128 grids
32 grids
32 grids

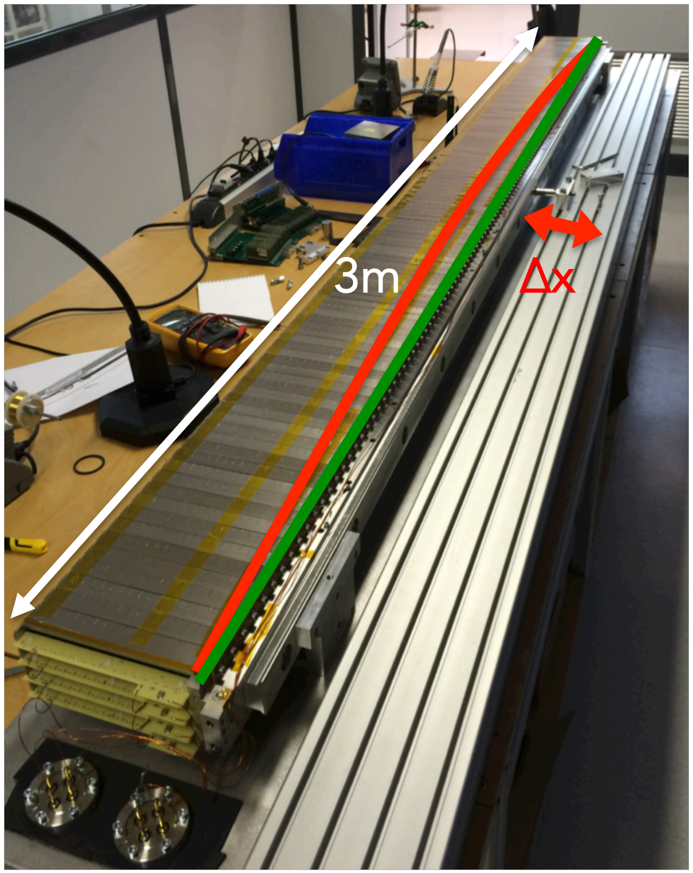


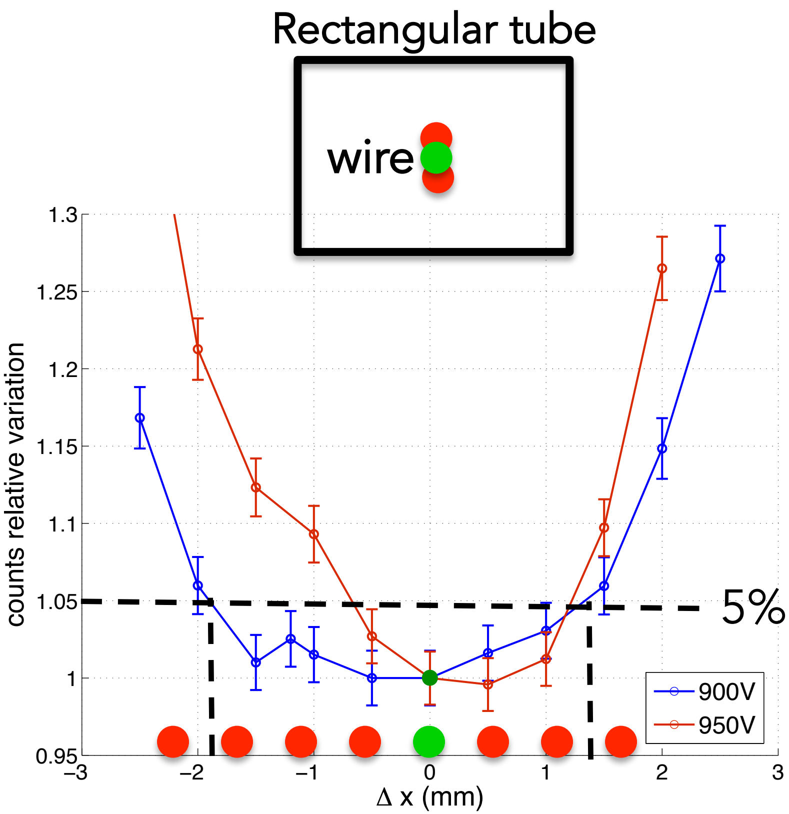




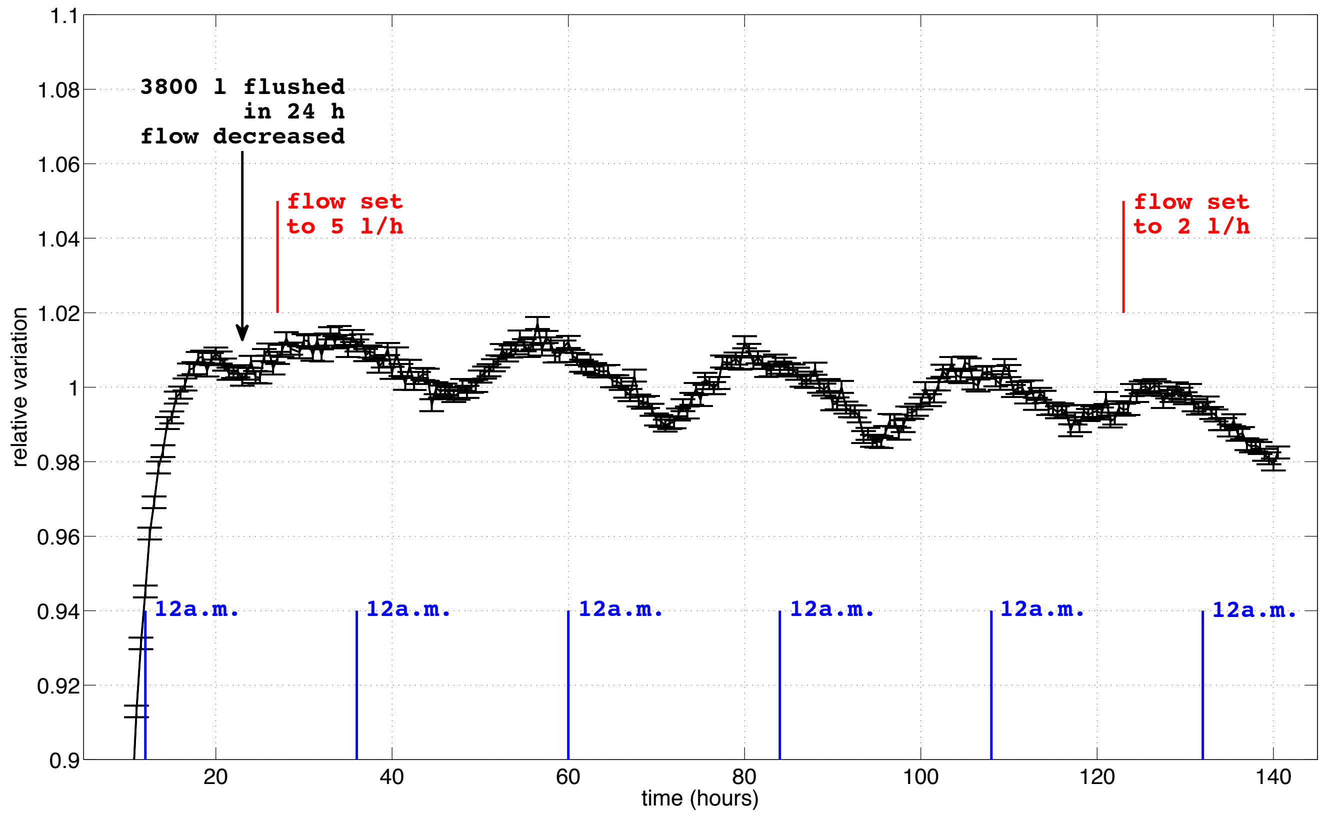


Amplification gain variation versus anode shifting





Counting stability versus time



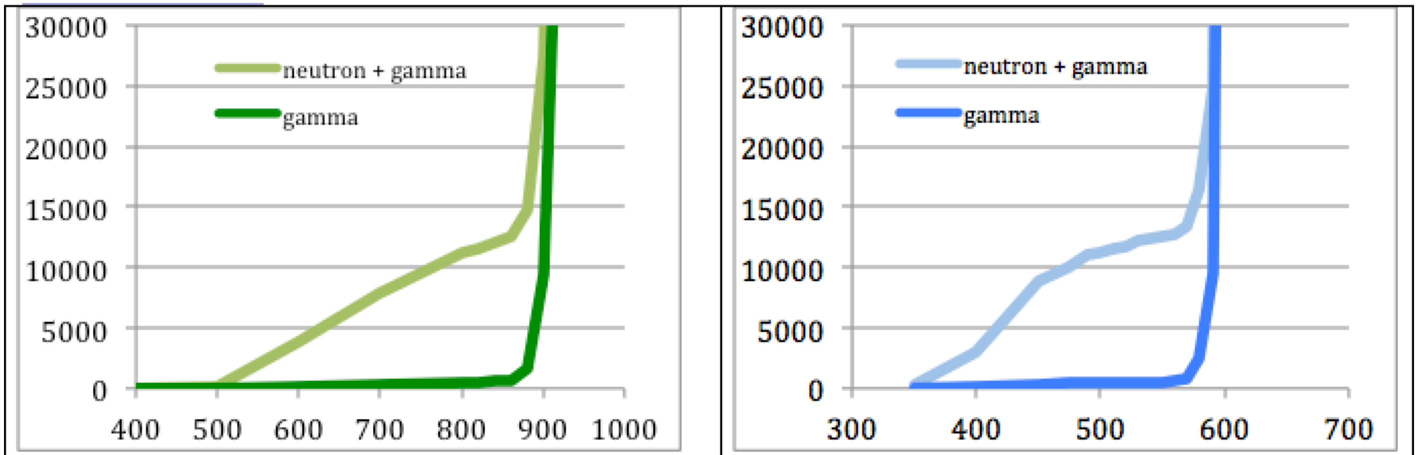
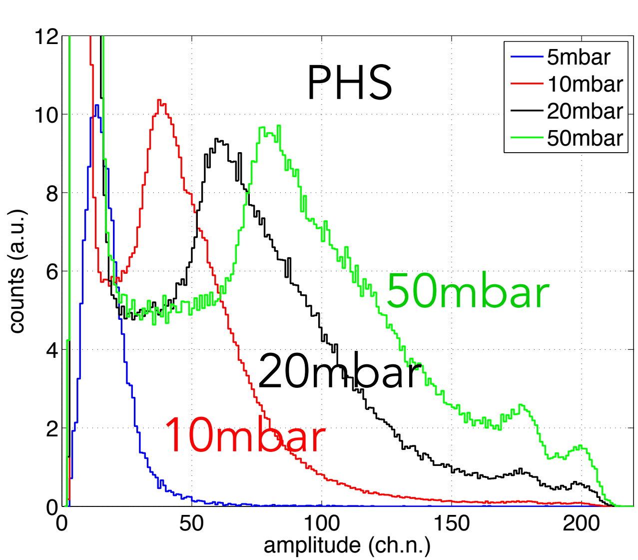
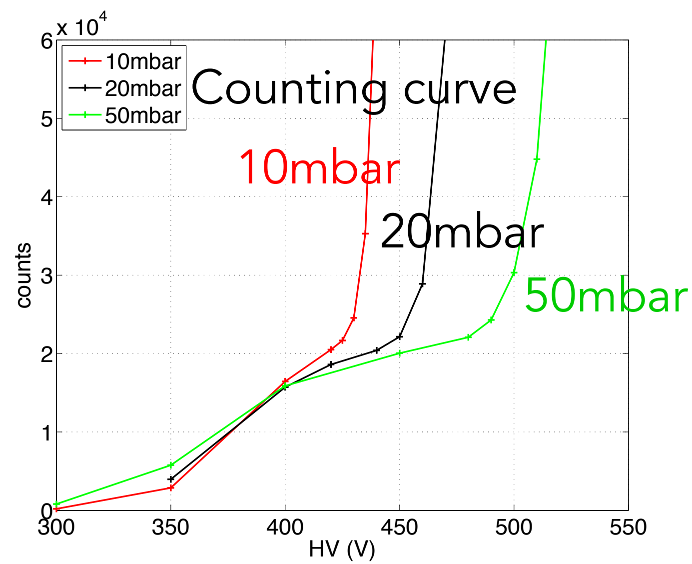
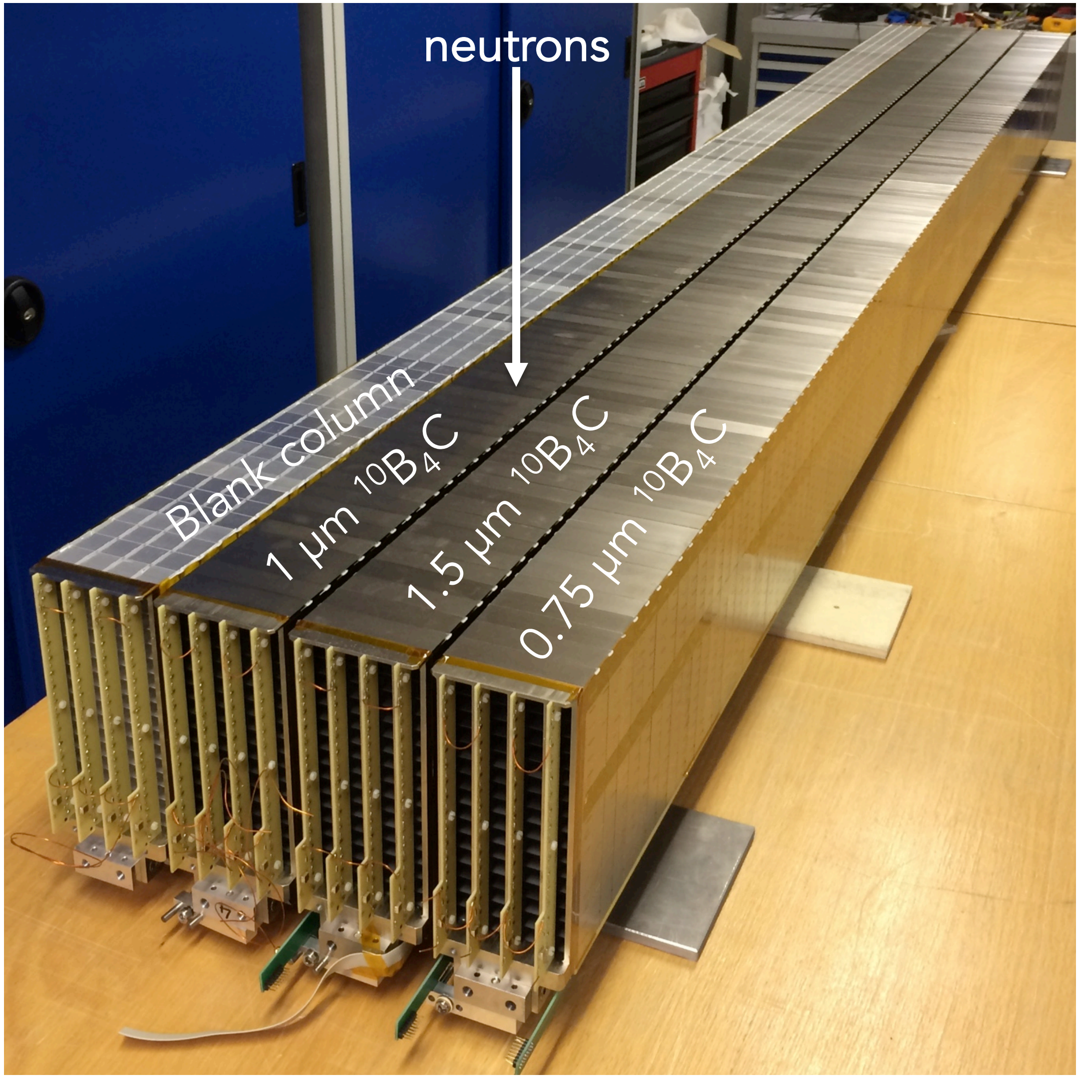
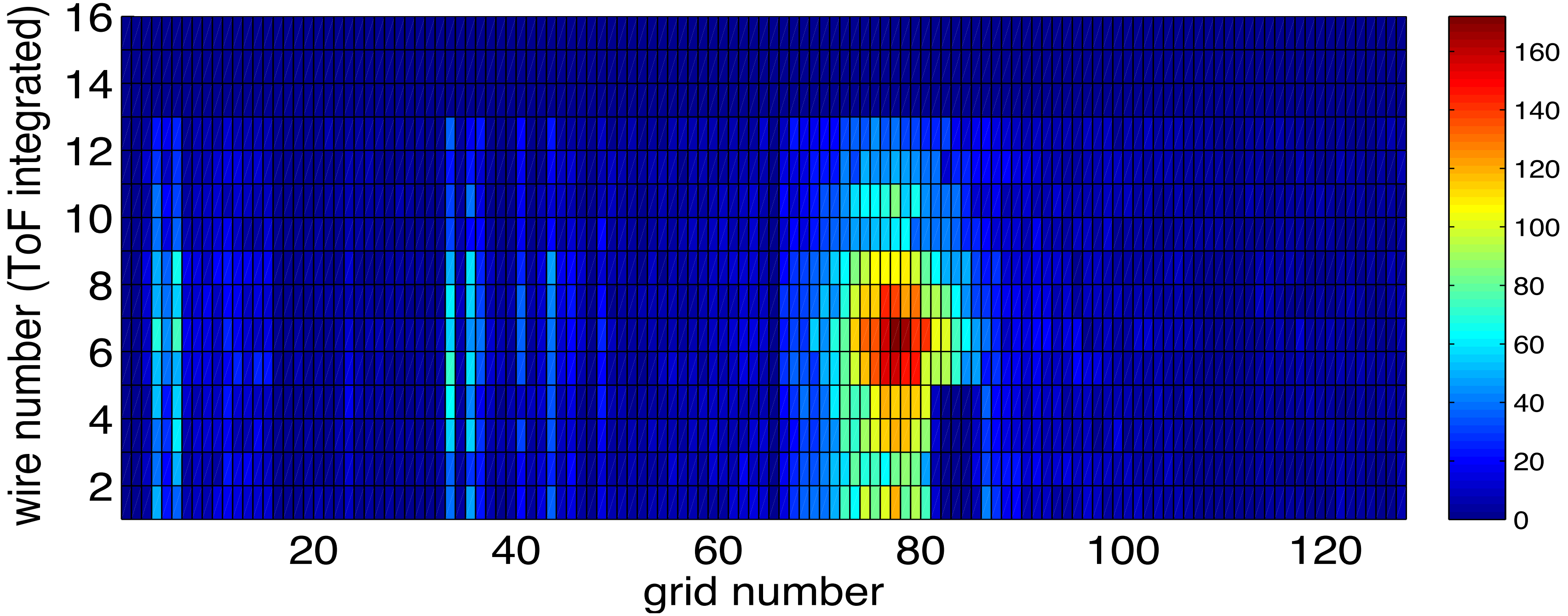


Figure 7: counting versus voltage curve for 1 bar (left) and 0.1 bar (right) of Ar-CO2






neutrons
Blank column
1 μm 10B4C
1.5 μm 10B4C
0.75 μm 10B4C


wire number (ToF integrated)
16
14
12
10
8
6
4
2
20
40
60
80
100
120
grid number
160
140
120
100
80
60
40
20
0

Conclusion

- Prototypes have been built and tested to measure key parameters for inelastic scattering TOF instruments: detection efficiency; gamma sensitivity; alpha and neutron background; counting stability.
- Measurements are in good agreement with the calculations and with the specifications.
- Production of B4C films has been optimized and industrialized
- The electronics readout scheme has been optimized to reduce the number of readout channels.
- A large area Multi-Grid demonstrator has been built and tested with 50% of the detection elements mounted. Its operation is compatible with vacuum operation.
- There is still room for improvement, in particular: reduce the dead zones, simplify connectics, increase the detection efficiency
- The Multi-Grid is robust and tolerant to mechanical defects; its production is accessible to standard labs or to the industry.

The 10-Boron Multi-Grid is an acceptable alternative to 3He detectors for future ESS instruments.

Boron-Multi-Grid detectors: What next ?

CRISP prototype: finish the mounting and testing/calibration

Use of existing CRISP grids in smaller/lighter detectors

New vessel design for low pressure operation (light + reduced cost)

New design: increase the number of films, minimize the dead space, …